KIDNEY PARENCHYMAL OXYGEN TENSION DETERMINED BY RENAL LYMPH CANNULATION

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Recent enthusiasm for renal lymph studies has been generated by a number of investigators.[1,2,3] We have previously observed a higher level of antibacterials in hilar lymph than in capsular lymph.[4,5] We have also reported increased renin-angiotensin levels in renal hilar lymph than in capsular lymph or renal vein plasma. Because of the peculiarities in blood flow within the kidney, our group felt that measurement of oxygen tension was indicated.

Direct methods for measuring kidney oxygen tension are subject to criticism. If a puncture technique with insertion of an oxygen microelectrode is employed, the data obtained will vary. Minimal hemorrhagic extravasation in the tissues from an adjacent venule or arteriole will affect the results. Similar criticism can be directed at reports[6,7] in which pelvic urine has been employed, for reducing substances such as ascorbic acid can affect the final reading.

Since lymph drains the interstitium it seemed reasonable to assume that renal lymph could serve as a more direct means of assessing tissue oxygen tension. Renal capsular lymph is comprised mainly of cortical tissue fluid; hilar lymph probably drains the medulla and the adjacent cortex.

METHODOLOGY

Healthy mongrel dogs weighing 15-28 kilograms were anesthetized by intravenous pentobarbital. An endotracheal tube was inserted and the dog was placed on air under positive pressure. Intravenous fluid, 1000 ml Ringer's solution, was infused over a four-hour period. One kidney was exposed through the flank and a renal capsular or hilar lymphatic vessel was cannulated. Details of our surgical technique have been published earlier. Cannulae (PE 50) of polyethylene were previously coated externally with an acetate covering. The distal end was then inserted into a special rubber stoppered vacuum tube filled with argon gas. Renal artery and renal vein blood samples were obtained by direct tap for measurement of oxygen tension.

Cisterna chyli lymph (4-8 ml) was obtained by direct aspiration in an additional 15 dogs. Oxygen tensions (PO_2) of cisterna chyli lymph, renal artery and renal vein blood were similarly determined. Aliquots of cisterna chyli lymph were additionally injected into vacuum tubes containing argon to test the effectiveness of the gas trap after 30 minutes and one hour.

Thoracic duct lymph was collected in eight separate animals by direct aspiration.

An astrup meter apparatus with an oxygen microelectrode was employed for the PO_2 measurements.

RESULTS

TABLE I CISTERNA CHYLI LYMPH OXYGEN TENSION

Number of Dogs	Cisterna Chyli PO_2 mm of Hg	Arterial PO_2 mm of Hg	Renal Vein PO_2 mm of Hg
15	59 ± 9	108 ± 6	61 ± 8

Cisterna chyli lymph oxygen tension was 59 ± 9 (S.D.) mm of Hg. Arterial and renal venous PO_2 are listed in Table I. The aliquots of cisterna chyli lymph kept in argon for 30 minutes and one hour respectively, did not change more than 1 mm of Hg.

TABLE II RENAL CAPSULAR LYMPH OXYGEN TENSION

Number of Dogs	Capsular Lymph PO_2 mm of Hg	Arterial PO_2 mm of Hg	Renal Vein PO_2 mm of Hg
7	78 ± 6	104 ± 5	60 ± 8

Renal capsular lymph oxygen tension was 78 ± 6 mm of Hg. Arterial and renal vein oxygen tension are listed.

TABLE III RENAL HILAR LYMPH OXYGEN TENSION

Number of Dogs	Hilar Lymph PO_2 mm of Hg	Arterial PO_2 mm of Hg	Renal Vein PO_2 mm of Hg
6	60 ± 8	109 ± 8	54 ± 6

A P value of less than 0.01 was obtained when comparing renal hilar and renal capsular lymph oxygen tensions.

TABLE IV THORACIC DUCT LYMPH OXYGEN TENSION

Number of Dogs	Thoracic Duct PO_2 mm of Hg	Arterial PO_2 mm of Hg	Renal Vein PO_2 mm of Hg
8	44 ± 8	101 ± 9	59 ± 10

Differences between thoracic duct lymph oxygen tension and cisterna chyli lymph are significant (P = less than .01).

Two experiments comparing lymph obtained from several regional lymphatic systems are illustrated in Figures 1 and 2. Oxygen tension is plotted in the ordinate. The same relationships are seen in each experiment. Capsular lymph oxygen tension is higher than hilar lymph or cisterna chyli lymph (fig. 1).

DISCUSSION

Renal capsular lymph has a significantly higher oxygen tension than hilar lymph (P = less than .01). Our findings support the present concept of plasma skimming[8] with separation of intrarenal blood flow. The renal cortex receives a larger cellular fraction of blood, whereas the medulla is probably supplied by a small segment (1/20 or less) of the renal blood flow. When lymph samples contained microscopic blood they were not included in the study. Oxygen tension of these few samples approached the arterial levels.

The cells of kidney tissue are dependent on an oxygen gradient involving partial pressures of dissolved gases diffusing between plasma and the interstitial compartment. Intracellular oxidative metabolism (enzyme kinetics) is a second important consideration when one considers diffusion of oxygen into lymph. Studies to determine oxidative enzymes affecting tissue respiration are indicated.

The cisterna chyli system represents a hub (fig. 3) which receives lymph from the kidney, portions of intestine retroperitoneal tissues, bony pelvis and lower extremities. Cisterna chyli lymph oxygen tension was not significantly lower than renal hilar lymph.

Thoracic duct lymph oxygen tension was significantly lower than the cisterna chyli fluid (P = less than .01). These oxygen tensions are also in agreement with thoracic duct measurements made by Witte et al.[9]

Lymph may be used to more directly assess tissue respiration. Underway in our laboratory are similar studies involving carbon dioxide tension measurements. These studies may also demonstrate a high level of metabolic activity in the renal cortex. It would appear that oxidative systems previously shown to be operative at the proximal tubular level, can be adequately explained by high tissue oxygen levels. In addition, the measurements of lowered oxygen tension in the medulla, when compared to the cortex, may account for it's increased susceptibility to pyelonephritic changes.

LEGEND

Figure 1. Bar graph plotting lymph oxygen tension from three compartments - renal capsular, renal hilar and cisterna chyli lymph.

Figure 2. Bar graph plotting cisterna chyli and thoracic duct oxygen tension. Pelvic urine oxygen tension is lower.

Figure 3. Cisterna chyli (see arrow) adjacent to inferior vena cava.

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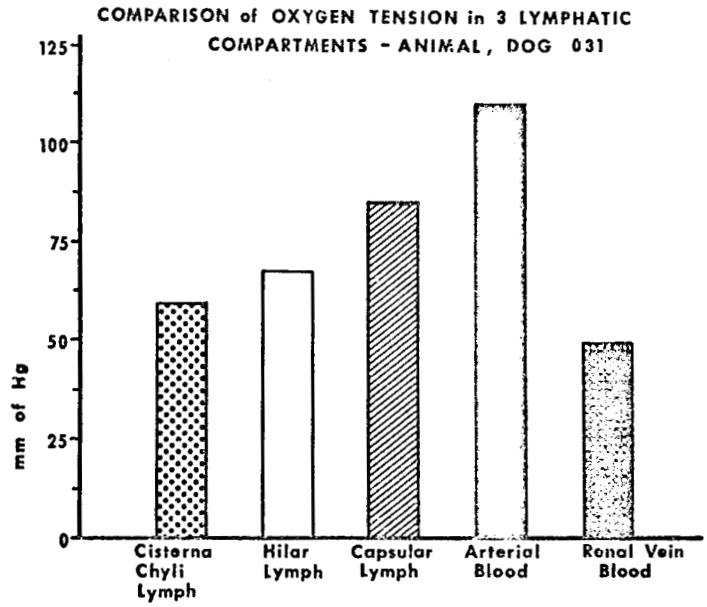

Figure 1

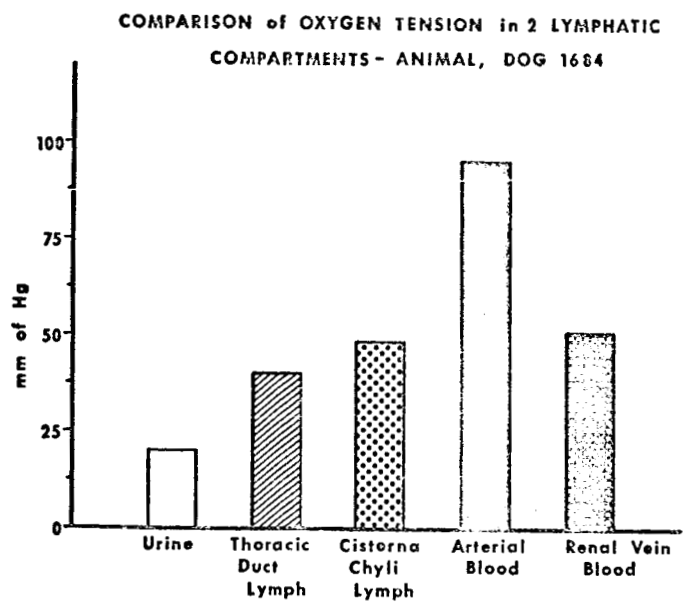

Figure 2

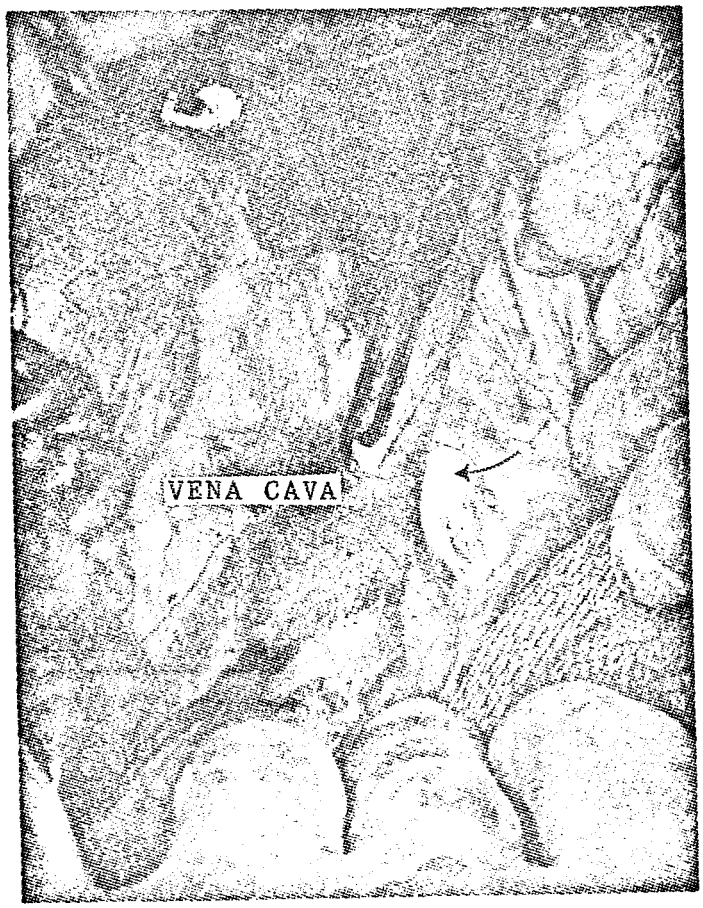

Figure 3